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## CAPABILITIES OF EXPERT SYSTEMS IN FORECASTING OPERATIONAL RISK FOR THE MOST COMMON INTERVENTIONS OF ABDOMINAL SURGERY (REVIEW)

### ABSTRACT

Literature review is devoted to the actual problem of the use of expert medical systems in abdominal surgery. The article describes in details the existing models of support systems for medical decisions in patients with such common diseases as acute pancreatitis, acute cholecystitis and complicated peptic ulcer disease. The authors made a comparative analysis of modern expert systems and described the basic principles of their construction. The problems of existing systems, analysis of the structure and mechanisms, underlying the design of decision support systems (DSS), examples of various options for building a DSS designed for use in the practice of a surgeon with a description of their key differences, advantages and disadvantages are outlined in article.

**Keywords:** expert systems, pancreatitis, pancreatic necrosis, peritonitis, artificial neural networks.

The increasing importance of information provision of various medical technologies becomes one of the critical factors of development in all fields of knowledge at the moment [11]. An expert system in surgery can be used for differential diagnosis and selection of intervention techniques and the assessment of vital parameters in real-time. According to Kolesnikov, D. L., wound infection is about 12 - 25% of all nosocomial infections, being one of the most common complications among all postoperative infectious complications. Up to 42% of all additional costs surgical hospitals associated with the treatment of wound infections. A particularly large number of septic complications observed in abdominal surgery [14]. In surgical practice when making medical decisions additionally should take into account such conditions as lack of time, high dynamics of the disease and other factors, significantly complicating the task of building computerized systems for decision support [18]. However, the most specific reproduction of the surgical intervention process with its analysis has become a new strategy for prevention and early diagnosis of complications [5].

Despite the variety of existing medical expert systems to support medical decisions in the surgery, most of them consider the possibility of their use in narrow enough spectrum of surgical diseases, in particular, surgical pathology of the abdominal region [5, 12, 13, 15, 16, 17, 20, 21, 22, 26, 29, 31, 35]. The most frequently used model of these systems is the artificial neural network (ANN). The advantages of ANN are the ability to better classify the data to increase the specificity of the method, without reducing its sensitivity. This structure for the processing of

cognitive information is based on the modeling of brain functions. The most important difference of ANN method is the possibility of constructing expert systems by a specialist, who can pass on their experience and the experience of colleagues, based on real clinical situations [11]. One of the first expert systems in surgery, based on neural network method, was intended to predict the duration of stay in hospital of patients with acute pancreatitis (Pofahl, 1998), diagnosis of acute pancreatitis the level of enzymes (Kazmierczak, 1993), prediction of lethal outcome (Halonen, 2003) [21]. Development B. Andersson and co-authors was aimed at assessing the effectiveness of artificial neural networks to predict the severity of acute pancreatitis on the basis of the six most informative criteria: heart rate, pain intensity, serum creatinine, hemoglobin, ALT and blood leukocytes [42].

Evaluation of the effectiveness of artificial neural networks in surgical practice was performed also by Russian researchers [15, 27]. A rapidly developing surgery of the new technologies, in particular, expanding opportunities for laparoscopic interventions, promote the steady development of information technologies in support of medical decision-making in this area. At the same time, mortality in various forms of pancreatitis varies widely, reaching from 25 to 65% with infected pancreatic necrosis [30]. In turn, the number of complications when performing laparoscopic procedures on an emergency basis is about 9%, and the informativeness of available rating scales (Ranson, SAPS, APACHE II), according to some authors, does not

provide individual prognosis for each specific clinical case [1, 25, 32]. Meanwhile, automated systems in abdominal surgery are becoming increasingly common, in particular, to quantify the risk of postoperative complications [6, 12, 13, 16, 17, 19, 29], evaluation of choice of method of surgical treatment [3, 10, 30], and also as a training system to study General surgery [8, 24, 28]. Key among the analyzed works is the development of Gurevich N. A. dedicated to the development of objective criteria to define and expand the limits of laparoscopic surgery with minimum risk of surgical complications. As the reasons of iatrogenic complications researchers have identified such factors as clinical and anatomic features (the severity of the inflammatory - infiltrative changes of pancreatoduodenal zone, atypical localization of vascular- ductal items), technical conditions, and experience of the surgeon. Presented software system allowed to improve intraoperative diagnosis and to avoid repeated interventions in a large sample of patients on the basis of the retrospective analysis of endoscopic images with the participation of surgeon-moderator [5]. The analysis of literature data allows to identify the most numerous group of informational developments in the field of pancreatology [5, 13, 16, 19, 20, 22, 29, 31, 35]. Despite these successes, the problem remains relevant because of the high frequency of hospitalization in emergency surgery [44]. According to some authors, the frequency of infectious complications after the intervention on the pancreas correlates with such indicators as duration of the disease, the lesion of the tissue of the

pancreas, the markers of systemic inflammation, type of surgical intervention [38,39,40,43]. The results of the microscopic and microbiological examinations of the material aspiration of pancreatic tissue, peripancreatic tissue and fluid accumulations were put in the basis of the "System for prediction of infected pancreatic necrosis" [20]. As input parameters were used the retrospective clinical, laboratory and instrumental examinations of 398 patients. The main output parameter in accordance with the task of computer modeling was sterile or infected pancreatic necrosis. As a diagnostic biological substrates took place in the mathematical model for predicting acute pancreatitis by A.V. Ivanov and a team was a selected set of trace elements (copper, zinc and iron), determined by atomic emission spectroscopy. The concentration of them was considered in conjunction with the electric resistance of biologically active points, connected with the disease "pancreatitis" [13]. The method of multivariate analysis using logistic regression was applied to the program "Automated accounting system of injuries of the pancreas" [35]. The authors have analyzed 109 35 quantitative and qualitative indicators, the key of which was demographic data, type and mechanism of injury, severity of the patient's condition, the number of damaged organs, blood loss, method of surgical treatment, complications, mortality. Distinctive characteristics of this development were the records of medical errors such as diagnostic delay (operation), technical mistakes (inadequate hemostasis), tactical mistakes (the increase in surgical intervention, inadequate drainage). Determinant factors in the development of specific postoperative complications have been identified by researchers (age characteristics of patients, mechanism of injury, tactical mistakes, type of intervention, exceeding the limits of laboratory values). The prognostic efficiency of this development was about 88.9%. A number of earlier authors when constructing predictive models of expert systems used as prognostic criteria the disturbance of cytokine regulation in acute pancreatitis and deviation of parameters of cellular immunity [9,23,33]. The main feature of the method of predicting acute

suppurative pancreatitis, developed by Hrachkov V. V., is a kind of "dynamic" models and the possibility of verification of current data with the regulatory indicators for the entire diagnostic and treatment process [34]. The system of criteria of severity used by Yudin V. N. (2009), divides all the prognostic signs into 3 classes based on their combination with the clinical picture of acute pancreatitis [37]. The basis of neuron-network model of Vinnik Yu. S. is set of examples with input parameters and pre-formulated answers with the indication of the forecast of pancreatic necrosis [2]. More recent work on the application SPVR during surgical interventions on the pancreas focused on the choice of method of surgical intervention, method of completion, risk assessment relaparotomy [3,13,16]. The risk of repeated surgery interventions in acute pancreatitis is about 10-40% of cases [7]. The forecasting system of re-intervention in the surgical treatment of severe acute pancreatitis using the method of sequential analysis of A. Wald developed by Krichmar, A. M. and coauthors. The index of forecast re-intervention is defined as sum of diagnostic factors. According to the developers, the greatest prognostic value belongs to indicators of systemic inflammatory reaction (leukocytosis of blood, PCT, LDH, CRP), presence of fluid collections or infiltration according to the ultrasound examination, hemorrhage in the peripancreatic tissue, the presence (or absence) of sequesters in the packing bag, the presence of devitalized areas in the pancreas by visual inspection and localization of the inflammatory process (lesion of pancreas head). [16]. An integral part of decision making in surgery is the qualifications of the doctor and his ability to assess the surgical risk. Consequently, modern expert systems should take into account not only objective clinical and laboratory parameters of surgical risk, but the level of professional standard of a surgeon. A rating of a surgeon is one of the basic components of a modern system of support of decision-making in abdominal surgery "Automated system for evaluation of treatment outcomes of patients with acute surgical pathology of abdominal organs" [3]. The authors of this expert system identified three factors influencing the risk of surgical intervention: the patient's condition,

complexity of the surgical intervention, level of experience of surgeon. The ranking surgeon was determined by two groups of parameters, which included formal characteristics (such as experience, qualification, academic degree etc.) and the actual results of the interventions. The choice of method of surgical approach, postoperative peritonitis is implemented in the "Computer expert system for prediction of the postoperative peritonitis" of Zharikov A. N. and co-authors. The program used 25 common options, consolidated into 4 groups of diagnostic criteria, reflecting the functional state of vitally important systems of homeostasis. According to the degree of deviation of these parameters the software allows to draw conclusions about the trends of the postoperative peritonitis in real time. The final forecast is calculated as a percentage of participation for each group of criteria and identifies 4 kinds of possible ways to address the adverse outcomes (sanation relaparotomy, the elimination of anastomotic failure or refusal of their application, removing enterostomy, the creation of decompressive laparoscopy) [10]. The evaluation scale of the state of the abdominal organs presented in the development of Savelyev V. S., referred to as "the Index of the abdomen." The basis of the method was 7 groups of factors, the main of which was the prevalence of peritonitis, the character of the exudate, the presence of adhesive process, the condition of the intestine and as a source of peritonitis. These indicators were used to select the indications for the choice of tactics of conducting the patient with peritonitis in mode laparotomy "on demand" or "program". In the framework of the expert system the authors developed quantitative assessment of bacterial and fungal infections of peritoneal exudates by flow cytometry. On the basis of comparison of results of microbiological analysis and the extent of involvement of the abdominal organs a pattern of conformity have established for the abdominal index and number of microorganisms in 1 ml. of exudate [30]. A free-standing problem in abdominal surgery is the estimation of surgical risk on the organs of the hepatobiliary zone. In the structure of acute surgical pathology as the complications of choledocholithiasis is included an acute cholecystitis with paravesical infiltrate, abscess,

perforation, obstructive jaundice, cholangitis, external or internal biliary fistula. During emergency interventions, the mortality due to complications of cholelithiasis reaches 12 %, when planned and delayed interventions - up to 1 % [36]. The practical application of existing assessment scales predict outcomes of surgical intervention in this disease is difficult because there is no possibility to integrate the results of scores of various clinical and diagnostic parameters in a single system and extrapolate them to the specific clinical situation [17].

In the modern system «Automated system for quantitative assessment of interventional risk» probability - statistical and neural network models are used. They aimed at the assessment of the preoperations severity in patients with cholelithiasis.

The result of processing the incoming data in the development is a "computer image" of the patient, which shows the relationship of the clinical picture with the empirical medicobiological data. The integration of these parameters is achieved by the possibility to quantify the severity of the clinical situation and the risk of surgical intervention [6]. In the framework of the study the results of laparoscopic cholecystectomy (LCE) were used by V.V.Zvyagintsev and coauthors to develop an expert system based on mathematical forecasting models, designed to predict the difficulty of the upcoming intervention, to change the composition of the operating team, to choose the technique of laparoscopic cholecystectomy and to prevent possible complications. These functions are combined in a computer system, predicting the complexity of the operation, containing as the basic principle encoding of the following characteristics: anamnestic data, ultrasound characteristics, clinical symptoms, laboratory data.

The purpose of this expert system is the ability to obtain information about the possibility of performing intervention, the complexity of the intervention, its expected duration, possible technical difficulties, and also to personalize the recommendations for more effective intervention based on the characteristics of the patient [12]. The task of predicting and evaluating the severity of acute cholecystitis based on fuzzy logic decision-making is implemented in the program of Korenevskiy N. and others. This model

of the expert system is based on the observation of significant changes in the quantitative composition of the trace element composition in blood of patients with acute cholecystitis. Revealed trends allowed the authors along with other useful features (clinical data, age, presence of comorbidity, the data of instrumental examination, laboratory data) to use quantitative cuprum, zinc and cobalt content in the blood for the predicting the occurrence, early diagnosis and severity of acute cholecystitis. [15]. Does not lose its relevance in the context of intra-abdominal interventions such a widespread problem as gastroduodenal bleeding (GDB) of various etiology. The proportion of peptic ulcer bleeding in the structure of GDB according to Holster I. L. and authors is 31-67% [41]. Bleeding of ulcer etiology, in turn, have the greatest chance of surgical treatment compared with GDB non-ulcer etiology [4]. The main factors of adverse outcomes of this disease are currently the frequent relapses, the patient's age and severe comorbidity. Data systematic review of Potakhin S. N. and co-authors suggest about the imperfection of the existing developments in the software developed to predict the risk of re-GDK. The programme of risk assessment used at the present stage, represented by a set of scales, based on the interpretation of endoscopic picture of the disease, or based solely on laboratory and clinical parameters. The sensitivity of these methods reaches about 99%, whereas the specificity is not beyond 30%, which inevitably increases the risk of hyperdiagnostics. The evolution of re-bleeding -risk evaluating methods observed in the predictive indices "Baylor Bleeding Score" and "Cedars – Sinai" (2012).

Despite the large number of review papers on the subject of comparative studies there are not enough Russian developments until recently as already today there are about 100 different scoring risk scales of recurrence of GDB, part of which is implemented in the form of computer programs. However, according to the author, none of the options does not meet the requirements of real clinical practice. In particular, existing assessment scales take into account a specific set of signs which not all cases can be public. The methodology needs to be simplified and easy to use and also have the opportunity to be integrated into

electronic medical records [26]. Thus, based on the data presented, we can confidently speak of a steadily evolving process of informatization of medical-diagnostic process in medicine in general and surgery in particular. The observed intensive informatization of medical institutions is an integral part of the development of personalised medicine, aimed at minimizing complications and risks, which is the cornerstone of successful intervention in surgical specialty.

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